

CLAIMS

1. A method for producing hydrogen comprising the steps of:
 - heating a fluid to turn into a high-pressure gas having a temperature in the range from 200°C or higher to 400°C or lower by heat exchange with a heat source;
 - feeding a raw material into a reactor;
 - instantaneously releasing the high-pressure gas into the reactor to generate a shock wave; and
 - impact-compressing the raw material by the shock wave to heat the raw material, to produce the hydrogen.
2. A method for producing hydrogen comprising the steps of:
 - heating a fluid to turn into a high-pressure gas having a pressure at least five times as high as the internal pressure of a reactor before reaction by heat exchange with a heat source;
 - feeding a raw material into the reactor;
 - instantaneously releasing the high-pressure gas into the reactor to generate a shock wave; and
 - impact-compressing the raw material by the shock wave to heat the raw material, to produce the hydrogen.
3. A method for producing hydrogen comprising the steps of:
 - heating a fluid having a low boiling-point to turn

into a high-pressure gas by heat exchange with a heat source;

feeding a raw material into a reactor;

instantaneously releasing the high-pressure gas into the reactor to generate a shock wave; and

impact-compressing the raw material by the shock wave to heat the raw material, to produce the hydrogen.

4. A method for producing hydrogen according to any one of Claims 1, 2, and 3, further comprising the step of separating the hydrogen from other products.

5. A method for producing hydrogen according to any one of Claims 1, 2, and 3, wherein the heat source is at least one selected from the group consisting of heat generating sources installed in thermal power plants, waste incineration plants, waste disposal plants, pig-iron making facilities in steel-making works, steel-making facilities of steel-making works, scrap melting facilities, nonferrous metal refining facilities, cement firing facilities, combustion facilities, and heat sources provided for using geothermal heat.

6. A method for producing hydrogen according to any one of Claims 1, 2, and 3, wherein the heat source is a

combustion facility that generates steam from the generated heat and that uses the steam for generating electric power.

7. A method for producing hydrogen according to any one of Claims 1, 2, and 3, wherein the heat source is a combustion facility that generates steam from the generated heat generated and that uses the steam for generating electric power, wherein the high-pressure gas is surplus steam.

8. An apparatus for producing hydrogen comprising:

 a heat source;

 a heat exchanger for heating a fluid to turn into a high-pressure gas having a temperature in the range from 200°C or higher to 400°C or lower by heat exchange with the heat source;

 a raw material feeder for feeding a raw material into a reactor; and

 the reactor for producing hydrogen by instantaneously releasing the high-pressure gas to generate a shock wave and impact-compressing the raw material by the shock wave to heat the raw material.

9. An apparatus for producing hydrogen comprising:

 a heat source;

 a heat exchanger for heating a fluid to turn into a

high-pressure gas having a pressure at least five times as high as the internal pressure of a reactor before reaction by heat exchange with the heat source;

a raw material feeder for feeding a raw material into the reactor; and

the reactor for producing hydrogen by instantaneously releasing the high-pressure gas to generate a shock wave and impact-compressing the raw material by the shock wave to heat the raw material.

10. An apparatus for producing hydrogen comprising:

a heat source;

a heater for heating a fluid having a low boiling-point to turn into a high-pressure gas;

a feeder for feeding a raw material into a reactor; and,

the reactor for producing hydrogen by instantaneously releasing the high-pressure gas to generate a shock wave and impact-compressing the raw material by the shock wave to heat the raw material.

11. An apparatus for producing hydrogen according to any one of Claims 8, 9, and 10, wherein the heat source is at least one selected from the group consisting of heat generating sources installed in thermal power plants, waste

incineration plants, waste disposal plants, pig-iron making facilities in steel-making works, steel-making facilities in steel-making works, scrap melting facilities, nonferrous metal refining facilities, cement firing facilities, combustion facilities, and heat sources for using geothermal heat.

12. An apparatus for producing hydrogen according to any one of Claims 8, 9, and 10, further comprising a separator for separating the hydrogen from other products.

13. An apparatus for producing hydrogen according to any one of Claims 8, 9, and 10, wherein the heat source is a combustion facility that generates steam from the generated heat and that uses the steam for generating electric power.

14. An apparatus for producing hydrogen according to any one of Claims 8, 9, and 10, wherein the heat source is a combustion facility that generates steam from the generated heat and that uses the steam for generating electric power, wherein the high-pressure gas is surplus steam.

15. A hydrogen supply plant comprising:

 a heat source;

 a steam generator for generating steam having a

temperature in the range from 200°C or higher to 400°C or lower by heat exchange with the heat source;

a raw material feeder for feeding a raw material into a reactor;

the reactor for producing hydrogen by instantaneously releasing the steam to generate a shock wave and impact-compressing the raw material by the shock wave to heat the raw material;

a separator for separating the hydrogen from a product containing the hydrogen produced in the reactor; and,

a device for supplying the separated hydrogen.

16. A hydrogen supply plant comprising:

a heat source;

a steam generator for generating steam having a pressure at least five times as high as the internal pressure of a reactor before reaction by heat exchange with the heat source;

a raw material feeder for feeding a raw material into the reactor;

the reactor for producing hydrogen by instantaneously releasing the steam to generate a shock wave and impact-compressing the raw material by the shock wave to heat the raw material;

a separator for separating the hydrogen from a

product containing the hydrogen produced in the reactor; and,
a device for supplying the separated hydrogen.

17. A hydrogen supply plant according to any one of Claim 15 or 16, wherein the heat source is a combustion facility that generates steam from the generated heat and that uses the steam for electric power generation, and wherein at least a part of the steam is used for producing the hydrogen when the hydrogen supply is required.

18. A method for generating electric power, comprising the steps of:

heating a fluid to turn into a high-pressure gas having a temperature in the range from 200°C or higher to 400°C or lower by heat exchange with a heat source;
feeding a raw material into a reactor;
instantaneously releasing the high-pressure gas into the reactor to generate a shock wave;
impact-compressing the raw material by the shock wave to heat the raw material, to produce gas that contains hydrogen; and
burning the gas that contains the hydrogen in a gas-turbine to generate electric power.

19. A method for generating electric power, comprising the

steps of:

heating a fluid to turn into a high-pressure gas having a pressure at least five times as high as the internal pressure of a reactor before reaction by heat exchange with a heat source;

feeding a raw material into the reactor;

instantaneously releasing the high-pressure gas into the reactor to generate a shock wave;

impact-compressing the raw material by the shock wave to heat the raw material, to produce gas that contains hydrogen; and

burning the gas that contains the hydrogen in a gas-turbine to generate electric power.

20. A method for generating electric power according to any one of Claim 18 or 19, further comprising the steps of:

storing the gas that contains the hydrogen; and controlling the amount of the generated electric power in accordance with demand for the electric power.

21. A method for producing hydrogen comprising the steps of:

feeding reactive particles containing a hydrocarbon or carbon into a compression chamber of a reactor;

feeding steam into the compression chamber of the

reactor;

reacting the reactive particles with the steam each other, by heating a mixture of the reactive particles and the steam fed into the compression chamber to a high temperature, to produce gas that contains hydrogen, wherein the reaction step comprises the step of reacting the reactive particles with the steam each other by impact-compressing the mixture in the compression chamber by a shock wave generated by jetting a high-pressure gas, and by heating the mixture in the compression chamber to a degree of a high temperature; and

separating the hydrogen from the gas that contains the hydrogen.

22. The method according to according to Claim 21, further comprising the step of feeding the steam as a high-pressure gas into the compression chamber.

23. The method according to any one of Claim 21 or 22, wherein the reactive particles comprise one selected from the group consisting of wasted plastic powder, sprayed particles of melted plastic, powdery coal, and coke breeze.

24. An apparatus for producing hydrogen, in which a mixture of reactive particles that contain a hydrocarbon or

carbon and that contain steam is heated to a degree of a high temperature to react, thereby producing gas that contains hydrogen, and in which the hydrogen is separated from the gas that contains the hydrogen, the apparatus comprising:

a compression chamber for accommodating the mixture of the reactive particles and the steam and compressing the mixture;

reactive particle feeding means for feeding the reactive particles into the compression chamber;

steam feeding means for feeding the steam into the compression chamber; and

shock-wave generating means for generating a shock wave for impact-compressing the mixture of the reactive particles fed into the compression chamber and the steam, wherein the shock-wave generating means includes:

a gas accommodation chamber for accommodating a high-pressure gas and communicating the high-pressure gas to the compression chamber; and

switching means for establishing and blocking a communication between the gas accommodation chamber and the compression chamber;

wherein the high-pressure gas in the gas accommodation chamber is instantaneously jetted by the switching means to generate the shock wave, and the shock wave is propagated

into the compression chamber and the mixture in the compression chamber is impact-compressed, to heat the mixture to a degree of a high temperature, thereby forcing the reactive particles and the steam to react for producing the gas that contains the hydrogen.

25. An apparatus for producing hydrogen according to Claim 24, further comprising:

compression chambers extending along the axis-direction of a rotatable revolution-body, located in a plurality of positions in the peripheral direction of the revolution body, the respective compression chambers having an opening at at least one end in the axis direction of the revolution-body; and,

switching means having a gas jetting port at a position in the radius direction of the compression chambers, the gas jetting port being allowed to communicate with the gas accommodation chamber by rotating the revolution body in which the gas jetting port is opposed to the openings of the compression chambers and an end-surface of the revolution body alternately, wherein the gas jetting port is closed by being opposed to the end-surface of the revolution body and wherein the gas jetting port is opened to establish a communication with the compression chamber by being opposed to one of the openings of the compression chambers;

wherein the shock wave of the high-pressure gas is intermittently propagated into the plurality of compression chambers by repeating a sequence of blocking and of establishing the communication.

26. An apparatus for producing hydrogen according to any one of Claim 24 or 25, further comprising steam feeding means through which the shock wave generating means accommodates the steam generated by a waste heat boiler as the high-pressure gas in the gas accommodation chamber.

27. An apparatus for producing hydrogen according to any one of Claims 24, 25, or 26, further comprising a Laval nozzle, a gas tank, a filter apparatus, and a hydrogen separator.